Sharka (Plum Pox Virus) Of Stone Fruit And Ornamental Prunus Species

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Introduction

Sharka or plum pox virus (PPV) is a serious disease of stone fruit. The disease was first observed on plums growing in Bulgaria from where the name Sharka (Slavic for plum pox) originated. It has spread throughout many European countries resulting in economic losses. The disease was recently found in a few stone fruit producing regions of North America. The exact route of Sharka introduction into Ontario is not known. As with the introduction into Pennsylvania, it was most likely brought in accidentally on infected propagation material, although other pathways of introduction are possible. Evidence suggests that the virus was introduced into Ontario as early as 1992.

The plum pox virus belongs to the family Potyviridae (potyvirus). Similar viral diseases in the potyvirus family include potato virus Y (PVY) and turnip mosaic virus (TuMV). The plum pox virus does not infect humans or animals.

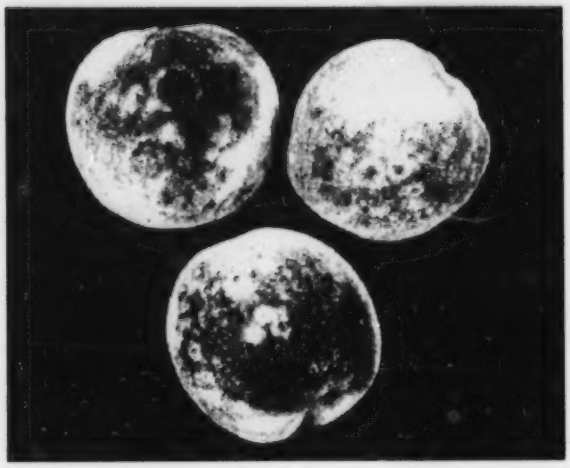

Figure 1. Sharka symptoms on infected peach fruit.

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Symptoms

Sharka disease symptoms vary and may be confused with other disorders such as nutrient deficiencies or injury caused by pesticides. Symptoms may appear on leaves, flowers, and fruit of all stone fruit (*Figure 1*) and occasionally on the pits of apricots. The expression of symptoms varies depending on the host, the cultivar, the strain of PPV, the age of the infected tree and the environment. Symptoms may be observed on only a few leaves or fruit, along one limb, or they may be expressed throughout the entire tree (*Figure 2*). In some years symptoms may appear in spring and early summer, but fade or disappear during periods of hot weather only to return again later in the season when temperatures moderate.

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Figure 2. Chlorotic blotches and spots on leaves of Sharka infected plum tree.

Leaf symptoms on infected trees include light chlorotic or yellow rings, spots, (*Figure 3*) and blotches, yellow line patterns along veins, vein clearing (*Figure 4*), and leaf distortion. On some cultivars, spots may appear as dead or necrotic tissue, while cther cultivars do not express obvious symptoms. Sensitive plum varieties may also show bark splitting. Occasionally, peach cultivars with showy flowers may display colour breaking on petals.

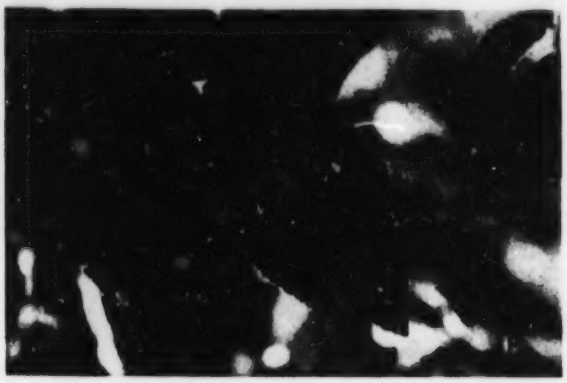

Figure 3. Leaf symptoms of Sharka include yellow rings on a) infected peach and spots and blotches on b) infected plum leaves.

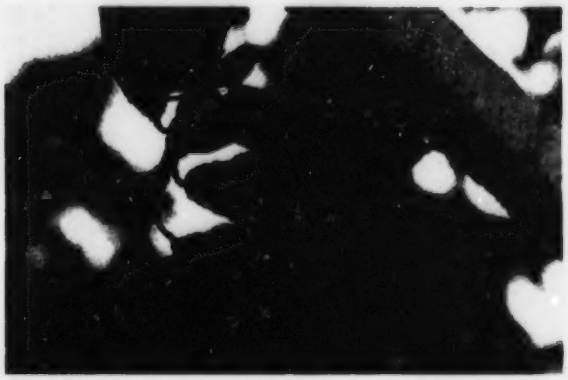

Figure 4. Yellow lines and vein clearing symptoms on Sharka infected peach leaf.

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Symptoms on green fruit of peach and nectarine appear as faint mottled yellow lines, patches and rings (*Figure 5*). As the fruit matures and ripens the lines, patches and rings remain yellow, surrounded by the normal blush colour (*Figure 6*). Because of the uneven distribution of the virus within the tree, different fruit on the same infected tree may appear symptom-less while other fruit appear severely diseased. Sugar content may also be affected in some cultivars, making the fruit less desirable for either fresh market or processing.

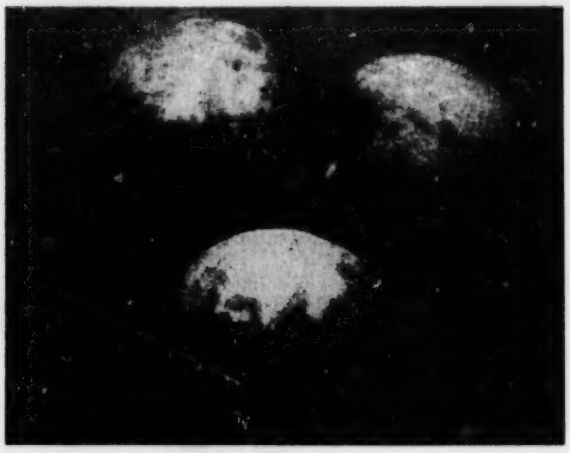

Figure 5. Faint mottled yellow lines, patches and rings on green fruit of Sharka infected peach.

Plum and apricot fruit are affected more severely than peach and nectarine. In addition to chlorotic rings, lines and spots, diseased plum and apricot fruit will become pocked and severely deformed. Rings and spots are occasionally observed on the pits of infected apricot fruit that may not display any external symptoms. Plum fruit are often severely deformed with dark sunken rings, and yield losses between 20%–30% have been reported on susceptible varieties in England. Sugar content is significantly reduced in infected fruit, which becomes pulpy, tasteless and unmarketable.

Infected trees rarely die but frequently become less productive as the disease progresses. A measurable decrease in growth has been observed on severely infected trees. Fruit may drop prematurely from infected trees depending on the host species, cultivar and PPV strain. Reports from Europe indicate fruit can drop 20–30 days before reaching normal maturity.

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Strains

The D (Dideron) strain is the most common, which was first isolated from apricots in France. It can also infect peaches, nectarines, and plums naturally and is well established in many European countries. The D strain is the only strain found in North America.

The M (Marcus) strain was first identified on peaches in Greece and can now be found in many European countries but not in North America. It is usually found on peaches but has been isolated from naturally-infected plums and apricots. Once established in a region, the M strain can spread quickly and is very difficult to eliminate.

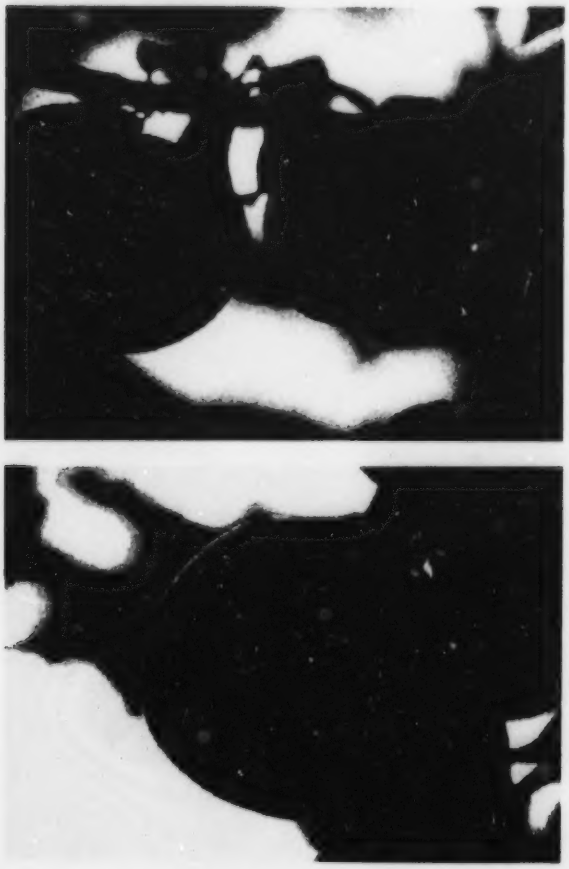

Figure 6. Yellow lines, rings (a) and blotches (b) on ripe peach fruit infected with Sharka.

The EA (El Amar) strain was originally isolated from apricots in Egypt but can also infect plums, nectarines and peaches. It has only been found in North African countries.

The C (Cherry) strain has only been isolated from sweet and sour cherries. The C strain is present in several European countries but has not been found in North America.

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Spread And Movement

The virus spreads between regions through the movement of infected propagating material (budwood, rootstocks or seedlings). Infected plant parts can be transported long distances, bypassing natural barriers such as mountain ranges, forests and oceans.

Roots of individual trees that come in contact with each other will often graft together and share common vascular tissue. The plum pox virus can also spread from infected trees to healthy trees through root grafts, but root grafts appear to be a minor method of spread. There is no evidence that the virus can be spread on pruning shears or knives. Seed transmission is possible but the frequency of occurrence is very low.

Aphid Transmission And Spread

Once Sharka becomes established within an orchard the virus spreads from tree to tree by several species of virus-carrying winged aphids. Aphids acquire the virus through feeding-related activities and then transmit it to nearby healthy plants. The efficiency of transmission largely depends upon the virus strain, the host species, the cultivar, and the aphid species. The D, EA, and C strains are not efficiently transmitted by aphids, and are considered the 'non-epidemic' form of the virus, whereas the M strain is transmitted efficiently by aphids and is considered the 'epidemic' form of Sharka.

Studies in European stone fruit orchards demonstrate that a wide range of aphid species is capable of transmitting the Sharka virus. Migrant aphid species that do not colonize stone fruit or *Prunus* spp. are considered important aphid vectors. Extremely high populations of specific migrant species may move into orchards looking for a food source after their preferred host crop matures or is harvested. It is not known which aphid species are present in Ontario orchards, nor how efficient they are as vectors (transmitters) of Sharka. However, many of the aphid species found in Ontario have been implicated in the spread of Sharka in Europe.

It is estimated that between 50,000–300,000 aphids visit a single fruit tree in a year. The probability of a healthy tree becoming infected with Sharka depends upon both the number of infected trees and the number of vectors occurring locally. Spread of Sharka in orchards can be relatively rapid, even where only the D strain is present. In the first years following introduction of Sharka in an orchard block, the number of infected trees is very low and the disease appears to spread very slowly. Once the level of infection reaches about 10%, however, the number of trees infected each following year increases very quickly. For this reason it is important to remove infected trees as soon as they are identified.

Targeting colonizing aphids that use peaches and nectarines as primary hosts (such as the green peach aphid) with insecticides may do little to reduce the spread of Sharka. There is considerable evidence from areas where PPV is prevalent in Europe that weekly applications of insecticides are not effective in preventing or alleviating the infection of disease-free orchards located close to infected ones. Because the virus is transmitted in a non-persistent manner, an aphid is able to transmit the virus in very short periods of feeding or 'testing'. Aphids may move in from neighbouring orchards or fields and rapidly contaminate the crop. Insecticides cannot kill immigrating aphids quickly enough to prevent acquisition and transmission, and thus regular sprays do not reduce their spread. In many instances application of insecticide results in higher rates of virus infection, possibly because aphids become agitated, probe more frequently, and disperse to adjacent plants.

Recently, researchers in France and the United States demonstrated that aphids could acquire and transmit the virus from infected fruit to young peach seedlings. The role of infected fruit in long distance spread of the virus requires more research. Regardless, it is important to properly dispose of stone fruit cull piles away from susceptible stone fruit orchards.

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Aphid Life Cycle

Aphids are small, soft-bodied insects that live in colonies (*Figure 7*) and feed on the internal sap of plant cells using modified piercing-sucking mouthparts or "stylets". Feeding activity on terminal leaves is readily apparent in the field as leaf curling (*Figure 8*). Aphids have complex life cycles that often include the development of winged and wingless forms (*Figure 9*), dependent upon environmental and host plant conditions. Winged adults are usually associated with migration from 1 crop or host plant to another throughout the growing season. Most aphid species live on 1 or a few related plants, however a few species spend winter, spring and fall on 1 plant type (primary host) and summer on unrelated plants (secondary hosts). In temperate regions such as Ontario, many aphid species overwinter in the egg stage on primary hosts. The green peach aphid (GPA) (*Figure 10*), for example, overwinters as eggs on peaches and nectarines. GPA eggs hatch in the spring to form wingless females. In late spring and early summer, subsequent generations of winged GPA females leave their primary hosts and colonize secondary hosts, which include several hundred species of vegetable crops, ornamentals, and weeds. In the fall, when temperatures drop, day length shortens, and plants grow slowly or die due to unfavourable environmental conditions, winged aphids (males and females) are produced, fly back to primary hosts where they eventually mate, lay eggs and die.

Although aphids are host–specific in their choice of food sources and plants on which to colonize, they are not capable of identifying suitable hosts visually, and will sample any plant they land on during migration. Sampling is accomplished by test probes, during which the aphid sticks its stylet into the plant epidermal (surface) cells, and sucks up a small quantity of the cell contents. Taste receptors indicate to the aphid if the plant is suitable as a host for feeding and colonization. If acceptable as a host plant, the aphid will initiate longer feeding probes. Aphid species incapable of reproducing on a given plant will sample foliage, find the plant distasteful, move on to sample a new host, and can in the process, acquire a plant virus and spread it from infected to healthy plants.

Figure 7. Colony of green peach aphids.

Figure 8. Damage on young peach tree leaves caused by green peach aphid feedings.

Figure 9. Winged and non-winged green peach aphids colonizing the underside of a peach leaf.

Figure 10. Non-winged green peach aphid.

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Naturally Infected Hosts

Most cultivated *Prunus* stone fruit tree species including apricots (*Prunus armeniaca*), common plum (*P. domestica*), Japanese plum (*P. salicina*), peach (*P. persica*), nectarine (*P. persica var. nucipersica*), and both sweet (*P. avium*) and sour cherry (*P. cerasus*) can be infected naturally by virus carrying aphids or through grafting contaminated bud wood. Host susceptibility and disease severity depends on the host species, cultivar as well as the strain of the virus.

Other hosts that can be infected in nature include wild plum (*P. americana*), cherry plum (*P. cerasifera*), dwarf flowering almond (*P. glandulosa*), and black thorn (*P. spinosa*). Infected trees can be a reservoir of the virus and should be destroyed immediately when found to protect susceptible non-infected trees in the region. For example black thorn has been a natural source of infection in several European countries.

Artificially Infected Hosts

Many *Prunus* species, including some popular ornamental shrubs such as flowering almond (*P. triloba*), manchu or nanking cherry (*P. tomentosa*), purple leaf sand cherry (*P. x cistena*), and sand cherry (*P. pumila*) have been artificially infected with the virus under special conditions during research experiments. Almond (*P. dulcis*), black walnut (*Juglans nigra*) and the native Canada plum (*P. nigra*) have also be artificially infected with PPV. There is no evidence that these hosts can be infected naturally and more research regarding their contribution to the overall spread of the virus and epidemiological importance is required.

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Herbaceous Hosts

In European studies, the plum pox virus has been isolated from several common herbaceous hosts including buttercup (*Ranunculus repens*), black medick (*Medicago lupulina*), red clover (*Trifolium pratense*), white clover (*Trifolium repens*) and bladder campion (*Silene vulgaris*). Several of these herbaceous hosts are common weeds in many regions of Ontario. The importance of susceptible weeds as a reservoir of the plum pox virus in North America is being investigated. Many studies in Europe indicate that weeds do not contribute significantly to the spread of the disease. Other herbaceous plants such as pea (*Pisum sativum*) cv. Colmo, tobacco (*Nicotiana tabacum*) and related *Nicotiana* species are also hosts and were often used as indicator plants to detect virus infection from diseased stone fruit plants.

Persistant and Non-Persistant Virus Transmission

Aphids transmit more than half of all plant viruses. There are 2 types of viral transmission by aphids: persistent and non-persistent transmission.

In persistent transmission, the aphid usually carries the virus for life. Uptake of the virus requires extended feeding; after an incubation period of several hours or days, the virus replicates and circulates within the insect. Thereafter, any feeding related activity could pass on the virus to new susceptible hosts. The spread of persistent viruses is favoured by aphid species that spend time in the crop. These include wingless individuals of aphid species that colonize and recognize the plant as a suitable host for at least part of the season. Controlling the aphid vectors with insecticides can significantly reduce the spread of persistent plant viruses.

In contrast, aphids can acquire non-persistent viruses, such as the plum pox virus, within a few seconds after sampling an infected plant. If they are winged migratory aphids and have found the plant unacceptable for feeding, they may move quickly from the infected plant onto a healthy plant, transmitting the virus in the process. Aphids usually retain the non-persistent viruses no more than an hour, but retention for up to 1–3 days has been reported. Aphids rapidly lose the virus particles after

the next test probe or feeding and must again sample an infected plant to continue to transmit the virus. If the next plant the aphid feeds on is not a Sharka host plant, then the virus is destroyed and the aphid is unable to transmit it to additional plants. A single aphid, therefore, cannot transmit the virus to more than one plant following acquisition of the virus.

Transient, non-colonizing, winged aphid species that sample many plants in search of appropriate hosts favour the transmission of non-persistent viruses such as plum pox virus. In contrast with persistent viruses, the spread is not reduced by insecticide applications. Non-winged colonizing aphids are probably not mobile enough to contribute substantially to the spread. Winged aphids moving through the orchard are more likely candidates responsible for transmission. Insecticides cannot kill immigrating aphids quickly enough to prevent acquisition and transmission, and thus regular sprays do not reduce the spread of non-persistent viruses.

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Surveys and Detection

Regular surveys are required to determine the presence and the distribution of the disease in a region or whether a region can be declared disease free. Inspecting trees visually for symptoms is not a reliable method for detecting all infection. Often infected trees do not show symptoms for up to 3 years after infection. Detection surveys are designed to detect at least one infected tree in an orchard or block with the least amount of sampling. The detection surveys do not provide information on the incidence or number of infected trees in an orchard or block.

Special laboratory tests such as the Enzyme Linked Immuno-Sorbent Assay (ELISA) and the Polymerase Chain Reaction (PCR) are required to detect low concentrations of the virus in tissues from plants not expressing symptoms. Frequently the tests are conducted on leaf samples; however, samples of other plant tissue including roots and bark have also been used. Due to the uneven distribution of the virus in infected trees, leaf samples should be taken from the previous year's growth in different quadrants of the trees. Recent studies indicate that the virus can be detected more frequently in leaf samples taken from inside the crown of the tree. The virus concentration is often reduced during prolonged periods of hot weather and leaf samples for surveys should be taken at the beginning of the growing season when temperatures are moderate.

Avoidance

Most stone fruit producing regions focus on preventing the introduction of Sharka into a disease-free region. It is everyone's responsibility to prevent the introduction of exotic pests including Sharka into regions where the pest does not naturally occur. Planting virus-free trees that are tested regularly from certified nurseries will help prevent the introduction of Sharka and other diseases into a disease free region. Regulations and enforcement to prevent the introduction of exotic pests on plant material coming into Canada from other countries are the responsibility of the Canadian Food Inspection Agency (CFIA).

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Quarantine

Many countries use quarantine as a method to exclude and prevent the introduction or spread of exotic pests such as Sharka into a disease free region or nation. Quarantine zones are placed around infected orchards or entire regions depending upon the distribution of the disease determined by detection surveys. Susceptible propagation material is prohibited from moving outside of the defined quarantine region, area or zone.

Eradication

If preventing the introduction of the disease into a disease-free region fails, the focus of the control strategy is removal of the pathogen by eliminating all infected trees. Once PPV becomes established in a region or in the wild native *Prunus* population, it is very difficult to eliminate the virus. Eradication involves surveying orchards and nurseries regularly and immediately removing infected trees before the virus spreads.

Management

Disease management is implemented only when prevention and eradication programs fail, or the disease becomes established in the native *Prunus* population of an infected region. The spread of PPV and other diseases by propagation can be reduced or eliminated by using virus-free budwood from a certified orchard. Various strategies are being implemented in infected regions of Europe to manage Sharka. Most management strategies involve regular surveys using visual symptoms to detect infected trees followed by their prompt removal in orchards with less than 10% infection. In France, trees are inspected visually for symptoms in the spring followed by several additional inspections throughout the season. Under a Sharka management program in England, plum orchards with more than 10% infected trees are usually destroyed entirely because they are more difficult to manage economically and threaten nearby orchards.

Insecticides used to control aphids do little to control the spread of Sharka. Their use also disrupts established pest management programs in stone fruit orchards, leading to increases in insecticide resistance and outbreaks of secondary pests. For these reasons, most European countries do not include insecticide sprays in Sharka management.

Weed management in and around susceptible orchards may slow down the spread of Sharka since some common weeds are natural hosts of PPV. However, the contribution of weeds to the spread of the disease is not clearly understood and more research is required to determine their importance in the spread, establishment and persistence of this disease in a region.

There are currently no commercially available varieties resistant to Sharka, however, disease management with resistant cultivars appears promising. Resistant genes have been identified and transferred to a plum cultivar. The transfer of these resistance genes to other stone fruit crops is challenging and time consuming using conventional breeding techniques. Genetic engineering and the use of biotechnology can help develop Sharka-resistant cultivars for most stone fruit crops.

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For more information consult the following Web sites:

- http://www.gov.on.ca/OMAFRA/english/crops/hort/sharka/sharka.htm
- http://sharka.cas.psu.edu/
- http://www.cas.psu.edu/docs/casdept/plant/ext/plumpoxv.html
- http://www.ento.vt.edu/Fruitfiles/plumpox.html
- http://www.apsnet.org/online/feature/PlumPox/Top.html

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